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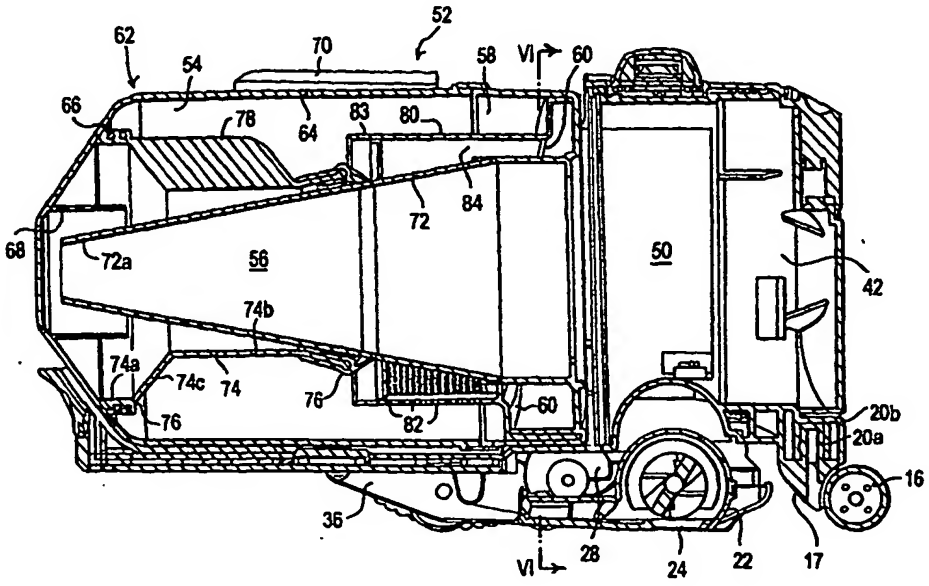

(57) Abstract

The invention provides a vacuum cleaner (10) having a dirty air inlet (24), a clean air outlet, an airflow path therebetween, and dirt and dust separating apparatus (52) arranged in the airflow path between the dirty air inlet (24) and the clean air outlet, the dirt and dust separating apparatus (52) comprising a centrifugal separator (54) having a cylindrical or tapering chamber (62) with a tangential inlet (32) at a first end and a dirt and dust collection portion at the second end opposite the first end, an inner wall (74) being located inside the second end of the cylindrical chamber (62), wherein the centrifugal separator (54) is located so that the longitudinal axis (18) of the cylindrical chamber (62) is horizontal and a single fin or baffle (78) is provided on the inner wall (74) so as to extend towards the wall of the cylindrical chamber (62) in a direction which is substantially parallel to that of the tangential inlet (32).

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Cyclonic Vacuum Cleaner

The invention relates to a cyclonic vacuum cleaner.

The term "cyclonic vacuum cleaner" is here intended to mean a vacuum cleaner having a dirty air inlet, a clean air outlet, an airflow path therebetween, and dirt and dust separating apparatus arranged in the airflow path between the dirty air inlet and the clean air outlet, the dirt and dust separating apparatus comprising a centrifugal separator having a cylindrical or tapering chamber with a tangential inlet at a first end and a dirt and dust collecting portion at a second end opposite the first end. In use, dirty air is drawn into the cleaner by means of a fan and motor unit through the dirty air inlet. The dirty air is passed to the centrifugal separator where it enters the cylindrical or tapering chamber via the tangential inlet. The dirt and dust is separated from the airflow within the chamber and collected in the dirt and dust collecting portion thereof whilst the clean air exits the cleaner via the clean air outlet.

The term "cyclonic vacuum cleaner" is applicable to any type of vacuum cleaner, including upright, cylinder or canister, backpack, industrial and robotic cleaners. Many types of cyclonic vacuum cleaner are known. Examples of cyclonic upright cleaners are shown and described in, *inter alia*, EP 0 042 723, EP 0 037 674, EP 0 636 338, US 4 593 429 and US Re 32 257. A cyclonic backpack cleaner is disclosed in US 5 267 371 and a cylinder cyclonic cleaner is disclosed in EP 0 778 745.

In all known cyclonic vacuum cleaners, the cyclone arrangement is such that, in normal modes of operation, the cyclone is orientated so that the longitudinal axis thereof is either vertical or inclined at an acute angle to the vertical. This is to allow the effects of gravity to assist the collection of the dirt and dust separated from the airflow. The collected dirt and dust drops to the end of the bin remote from the inlet and is collected there. In some arrangements, the cyclonic separator includes two (or more) cyclones. However, in all cases, both or all of the cyclones are arranged so that the axes of the cyclones are, in the normal mode of operation, vertical or inclined at an acute angle to

the vertical so that the effects of gravity can be put to good use in assisting the separation and collection of the separated dirt and dust.

There are instances when the vertical height of a vacuum cleaner is preferably kept to a minimum, for example when the vacuum cleaner is required to be used underneath articles of furniture or in other areas where there is a height restriction. Vacuum cleaners of the type already known can be used for short periods in a mode which brings the cyclonic separator into or near to a horizontal position (ie with the axis of the cyclone lying horizontally), but the effects of gravity are then lost and the orientation of the cyclone and its collecting chamber or bin can result in rdeuced separation efficiency of the cyclone. It is therefore generally understood that a cyclone which is orientated with its axis lying horizontally is not as efficient at separating dirt and dust from an airflow as one which has its axis arranged vertically, or at most inclined at an acute angle to the vertical.

It is therefore an object of the invention to provide a cyclonic vacuum cleaner which is more compact in the vertical direction than known vacuum cleaners. It is a further object of the present invention to provide a cyclonic vacuum cleaner which is capable of cleaning within confined areas having height restrictions. It is a still further object of the invention to provide a vacuum cleaner which has a smaller vertical dimension than comparable known cleaners whilst still achieving a high separation efficiency.

The invention provides a vacuum cleaner having a dirty air inlet, a clean air outlet, an airflow path therebetween, and dirt and dust separating apparatus arranged in the airflow path between the dirty air inlet and the clean air outlet, the dirt and dust separating apparatus comprising a centrifugal separator having a cylindrical or tapering chamber with a tangential inlet at a first end and a dirt and dust collecting portion at a second end opposite the first end, an inner wall being located inside the second end of the chamber, wherein the centrifugal separator is located so that the longitudinal axis of the chamber is horizontal and a single fin or baffle is provided on the inner wall so as to

extend towards the wall of the chamber in a direction which is substantially parallel to that of the tangential inlet.

The provision of the single fin or baffle extending from the inner wall towards the wall of the chamber provides a baffle against which dirt and dust separated in the cyclone can accumulate. The constant airflow within the chamber presses the separated dirt and dust against the fin or baffle and a build-up of dirt and dust occurs. Arranging the fin or baffle so that it lies parallel to the tangential inlet allows the chamber to be filled to maximum capacity before overfilling can occur. The location of the fin or baffle at an uppermost point within the chamber means that the initial build-up of dirt and dust is located in that area. As the build-up of dirt and dust continues, the accumulated dirt and dust builds up around the inner wall and the accumulation is relatively even and uniform.

Preferably, the fin or baffle is located on a portion of the inner wall remote from the first end of the chamber. This assists in the build-up of dirt and dust in a generally helical manner so that the maximum amount of separated dirt and dust can be accommodated in the chamber before the dirt and dust is collected in a position which is unacceptably close to the incoming and/or outgoing airflow, which could result in re-entrainment occurring.

It has been found to be preferable if the fin or baffle extends across substantially half of the distance between the inner wall and the wall of the chamber, although the same effect could be achieved if the extent of the fin or baffle were between one quarter and three quarters of that distance.

Another preferable feature has been found to be the location of the inlet to the centrifugal separator in a tangential manner above the lowermost edge of the chamber. This further reduces the risk of re-entrainment of separated dirt and dust into the incoming or outgoing airflow. More preferably, the tangential inlet is located along or parallel to a vertical tangent to the wall of the chamber.

A preferred application of the cleaner according to the invention is in the field of robotic vacuum cleaners, ie cleaners which carry navigation equipment and sensors which will allow the vacuum cleaner to navigate itself around a room or other area to be cleaned without human intervention. In such an application, the vacuum cleaner will include supporting wheels, drive means for driving the wheels, sensors for sensing objects in the path of the cleaner and control means for avoiding contact with any such objects. However, the invention is applicable to vacuum cleaners which are not robotic in nature.

Further features and advantages of the invention will become apparent from the following description of an embodiment of the invention, which is given by way of example only and is not intended to be limiting, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a vacuum cleaner according to the invention;

Figure 2 is a plan view of the vacuum cleaner of Figure 1;

Figure 3 is a rear view of the vacuum cleaner of Figure 1;

Figure 4 is a side view of the vacuum cleaner of Figure 1;

Figure 5 is an underneath view of the vacuum cleaner of Figure 1;

Figure 6 is a sectional view taken along the line V-V of Figure 2; and

Figure 7 is a sectional view taken along the line VI-VI of Figure 6 showing only the cleaner head and the cyclonic separator of the vacuum cleaner of Figure 1.

The vacuum cleaner 10 shown in the drawings has a supporting chassis 12 which is generally circular in shape and is supported on two driven wheels 14 and a castor wheel 16. The chassis 12 is preferably manufactured from high-strength moulded plastics material, such as ABS, but can equally be made from metal such as aluminium or steel. The chassis 12 provides support for the components of the cleaner 10 which will be described below. The driven wheels 14 are arranged at either end of a diameter of the chassis 12, the diameter lying perpendicular to the longitudinal axis 18 of the cleaner 10. Each driven wheel 14 is moulded from a high-strength plastics material and carries

a comparatively soft, ridged band around its circumference to enhance the grip of the wheel 14 when the cleaner 10 is traversing a smooth floor. The soft, ridged band also enhances the ability of the wheels to mount or climb over small obstacles. The driven wheels 14 are mounted independently of one another via support bearings (not shown) and each driven wheel 14 is connected directly to a motor 15 which is capable of driving the respective wheel 14 in either a forward direction or a reverse direction. By driving both wheels 14 forward at the same speed, the cleaner 10 can be driven in a forward direction. By driving both wheels 14 in a reverse direction at the same speed, the cleaner 10 can be driven in a backward direction. By driving the wheels 14 in opposite directions, the cleaner 10 can be made to rotate about its own central axis so as to effect a turning manoeuvre. The aforementioned method of driving a vehicle is well known and will not therefore be described any further here.

The castor wheel 16 is significantly smaller in diameter than the driven wheels 14 as can be seen from, for example, Figure 4. The castor wheel 16 is not driven and merely serves to support the chassis 12 at the rear of the cleaner 10. The location of the castor wheel 16 at the trailing edge of the chassis 12, and the fact that the castor wheel 16 is swivellingly mounted on the chassis by means of a swivel joint 20, allows the castor wheel 16 to trail behind the cleaner 10 in a manner which does not hinder the manoeuvrability of the cleaner 10 whilst it is being driven by way of the driven wheels 14. The swivel joint 20 is most clearly shown in Figure 6. The castor wheel 16 is fixedly attached to an upwardly extending cylindrical member 20a which is received by an annular housing 20b to allow free rotational movement of the cylindrical member 20a therewithin. This type of arrangement is well known. The castor wheel 16 can be made from a moulded plastics material or can be formed from another synthetic material such as Nylon.

Mounted on the underside of the chassis 12 is a cleaner head 22 which includes a suction opening 24 facing the surface on which the cleaner 10 is supported. The suction opening 24 is essentially rectangular and extends across the majority of the width of the cleaner head 22. A brush bar 26 is rotatably mounted in the suction opening 24 and a

motor 28 is mounted on the cleaner head 22 for driving the brush bar 26 by way of a drive belt (not shown) extending between a shaft of the motor 28 and the brush bar 26. The cleaner head 22 is mounted on the chassis 12 in such a way that the cleaner head 22 is able to float on the surface to be cleaned. This is achieved in this embodiment in that the cleaner head 22 is pivotally connected to an arm (not shown) which in turn is pivotally connected to the underside of the chassis 12. The double articulation of the connection between the cleaner head 22 and the chassis 12 allows the cleaner head to move freely in a vertical direction with respect to the chassis 12. This enables the cleaner head to climb over small obstacles such as books, magazines, rug edges, etc. Obstacles of up to approximately 25mm in height can be traversed in this way. A flexible connection 30 (see Figure 7) is located between a rear portion of the cleaner head 22 and an inlet port 32 (see also Figure 7) located in the chassis 12. The flexible connection 30 consists of a rolling seal, one end of which is sealingly attached to the upstream mouth of the inlet port 32 and the other end of which is sealingly attached to the cleaner head 22. When the cleaner head 22 moves upwardly with respect to the chassis 12, the rolling seal 30 distorts or crumples to accommodate the upward movement of the cleaner head 22. When the cleaner head 22 moves downwardly with respect to the chassis 12, the rolling seal 30 unfolds or extends into an extended position to accommodate the downward movement.

In order to assist the cleaner head 22 to move vertically upwards when an obstacle is encountered, forwardly projecting ramps 36 are provided at the front edge of the cleaner head 22. In the event that an obstacle is encountered, the obstacle will initially abut against the ramps 36 and the inclination of the ramps will then lift the cleaner head 22 over the obstacle in question so as to avoid the cleaner 10 from becoming lodged against the obstacle. The cleaner head 22 is shown in a lowered position in Figure 6 and in a raised position in Figure 4. The castor wheel 16 also includes a ramped portion 17 which provides additional assistance when the cleaner 10 encounters an obstacle and is required to climb over it. In this way, the castor wheel 16 will not become lodged against the obstacle after the cleaner head 22 has climbed over it.

As can be seen from Figures 2 and 5, the cleaner head 22 is asymmetrically mounted on the chassis 12 so that one side of the cleaner head 22 protrudes beyond the general circumference of the chassis 12. This allows the cleaner 10 to clean up to the edge of a room on the side of the cleaner 10 on which the cleaner head 22 protrudes.

The chassis 12 carries a plurality of sensors 40 which are designed and arranged to detect obstacles in the path of the cleaner 10 and its proximity to, for example, a wall or other boundary such as a piece of furniture. The sensors 40 comprise several ultra-sonic sensors and several infra-red sensors. The array illustrated in Figures 1 and 4 is not intended to be limitative and the arrangement of the sensors does not form part of the present invention. Suffice it to say that the vacuum cleaner 10 carries sufficient sensors and detectors 40 to enable the cleaner 10 to guide itself or to be guided around a predefined area so that the said area can be cleaned. Control software, comprising navigation controls and steering devices, is housed within a housing 42 located beneath a control panel 44 or elsewhere within the cleaner. Battery packs 46 are mounted on the chassis 12 inwardly of the driven wheels 14 to provide power to the motors for driving the wheels 14 and to the control software. The battery packs 46 are removable to allow them to be transferred to a battery charger (not shown).

The vacuum cleaner 10 also includes a motor and fan unit 50 supported on the chassis 12 for drawing dirty air into the vacuum cleaner 10 via the suction opening 24 in the cleaner head 22. The chassis 12 also carries a cyclonic separator 52 for separating dirt and dust from the air drawn into the cleaner 10. The features of the cyclonic separator 52 are best seen from Figures 6 and 7. The cyclonic separator 52 comprises an outer cyclone 54 and an inner cyclone 56 arranged concentrically therewith, both cyclones 54,56 having their coaxial axes lying horizontally. The outer cyclone 54 comprises an entry portion 58 which communicates directly with the inlet port 32 as shown in Figure 7. The inlet port 32 and the entry portion 58 together provide an entry into the outer cyclone 54 which is tangential. The direction of the tangential inlet is vertically upward, as shown in Figure 7. It will also be seen from Figure 7 that the inlet, particularly the lower edge 33 thereof, is located so that it is above the lowermost edge

or side 35 of the outer cyclone 54. This helps to prevent re-entrainment of dirt and dust into the airflow during operation. The entry portion 58 which is cylindrical and has an end wall 60 which is generally helical. The entry portion 58 opens directly into a cylindrical bin 62 having an outer wall 64 whose diameter is the same as that of the entry portion 58. The cylindrical bin 62 is made from a transparent plastics material to allow a user to view the interior of the outer cyclone 54. The end of the bin 62 remote from the entry portion 58 is frusto-conical in shape and closed. A locating ring 66 is formed integrally with the end of the bin at a distance from the outer wall 64 thereof and a dust ring 68 is also formed integrally with the end of the bin 62 inwardly of the locating ring 66. Located on the outer surface of the bin 62 are two opposed gripper portions 70 which are adapted to assist a user to remove the separator 52 from the chassis 12 for emptying purposes. Specifically, the gripper portions 70 are moulded integrally with the transparent bin 62 and extend upwardly and outwardly from the outer wall 64 so as to form an undercut profile as shown in Figure 1.

The inner cyclone 56 is formed by a partially-cylindrical, partially-frusto-conical cyclone body 72 which is rigidly attached to the end face of the entry portion 58. The cyclone body 72 lies along the longitudinal axis of the transparent bin 62 and extends almost to the end face thereof so that the distal end 72a of the cyclone body 72 is surrounded by the dust ring 68. The gap between the cone opening at the distal end 72a of the cyclone body 72 and the end face of the bin 62 is preferably less than 8mm.

A fine dust collector 74 is located in the bin 62 and is supported by the locating ring 66 at one end thereof. The fine dust collector 74 is supported at the other end thereof by the cyclone body 72. Seals 76 are provided between the fine dust collector 74 and the respective support at either end. The fine dust collector 74 has a first cylindrical portion 74a adapted to be received within the locating ring 66, and a second cylindrical portion 74b having a smaller diameter than the first cylindrical portion 74a. The cylindrical portions 74a, 74b are joined by a frusto-conical portion 74c which is integrally moulded therewith.

A single fin or baffle 78 is moulded integrally with the fine dust collector 74 and extends radially outwardly from the second cylindrical portion 74b and from the frusto-conical portion 74c (see Figure 6). The outer edge 78a of the fin 78 is aligned with the first cylindrical portion 74a and also with the wall of the shroud 80. The inclined edge 78b of the fin 78 remote from the first cylindrical portion 74a lies essentially parallel to the frusto-conical portion 74c. The outer and inclined edges 78a, 78b are joined by a smooth curve moulded into the fin 78.

The single fin 78 extends upwardly from the fine dust collector 74. The angle at which the fin extends can be varied within certain limits and it is not intended that the fin may only extend upwardly at 90° to a horizontal plane. However, the capacity of the bin 62 is put to the best use if the fin 78 does extend from the fine dust collector generally upwardly towards the wall of the bin 62. The radial extent of the fin 78 may also vary. In the illustrated embodiment, the fin 78 extends approximately one half of the distance between the fine dust collector and the bin 62, although it is envisaged that this distance could be varied between one quarter and one half of the said distance

A shroud 80 is located between the first and second cyclones 54, 56. The shroud 80 is cylindrical in shape and is supported at one end by the entry portion 58 and by the cyclone body 72 of the inner cyclone 56 at the other end. As is known, the shroud 80 has perforations 82 extending therethrough and a lip 83 projecting from the end of the shroud 80 remote from the entry portion 58. A channel 84 is formed between the shroud 80 and the outer surface of the cyclone body 72, which channel 84 communicates with an entry port 86 leading to the interior of the inner cyclone 56 in a manner which forces the incoming airflow to adopt a swirling, helical path. This is achieved by means of a tangential or scroll entry into the inner cyclone 56 as can be seen from Figure 7. A vortex finder (not shown) is located centrally of the larger end of the inner cyclone 56 to conduct air out of the cyclonic separator 52 after separation has taken place. The exiting air is conducted past the motor and fan unit 50 so that the motor can be cooled before the air is expelled to atmosphere. Additionally, a post-motor filter (not shown) can be provided downstream of the motor and fan unit 50 in

order to further minimise the risk of emissions into the atmosphere from the vacuum cleaner.

The entire cyclonic separator 52 is releasable from the chassis 12 in order to allow emptying of the outer and inner cyclones 54, 56. A hooked catch (not shown) is provided adjacent the inlet port 32 by means of which the cyclonic separator 52 is held in position when the cleaner 10 is in use. When the hooked catch is released (by manual pressing of a button 34 located in the control panel 44), the cyclonic separator 52 can be lifted away from the chassis 12 by means of the gripper portions 70. The bin 62 can then be released from the entry portion 58 (which carries with it the shroud 80 and the inner cyclone body 72) to facilitate the emptying thereof.

The vacuum cleaner 10 described above operates in the following manner. In order for the cleaner 10 to traverse the area to be cleaned, the wheels 14 are driven by the motors 15 which, in turn, are powered by the batteries 46. The direction of movement of the cleaner 10 is determined by the control software which communicates with the sensors 40 which are designed to detect any obstacles in the path of the cleaner 10 so as to navigate the cleaner 10 around the area to be cleaned. Methodologies and control systems for navigating a robotic vacuum cleaner around a room or other area are well documented elsewhere and do not form part of the inventive concept of this invention. Any of the known methodologies or systems could be implemented here to provide a suitable navigation system.

The batteries 46 also provide power to operate the motor and fan unit 50 to draw air into the cleaner 10 via the suction opening 24 in the cleaner head 22. The motor 28 is also driven by the batteries 46 so that the brush bar 26 is rotated in order to achieve good pick-up, particularly when the cleaner 10 is to be used to clean a carpet. The dirty air is drawn into the cleaner head 22 and conducted to the cyclonic separator 52 via the telescopic conduit 30 and the inlet port 32. The dirty air then enters the entry portion 58 in a tangential manner and adopts a helical path by virtue of the shape of the helical wall 60. The air then spirals down the interior of the outer wall 64 of the bin 62 during

which motion any relatively large dirt and fluff particles are separated from the airflow. The separated dirt and fluff particles collect in the end of the bin 62 remote from the entry portion 58.

The fin 78 discourages uneven accumulation of dirt and fluff particles and helps to distribute the dirt and fluff collected around the end of the bin 62 in a relatively even manner. It achieves this by providing a baffle against which dirt and dust separated in the outer cyclone 54 can accumulate. The constant airflow within the bin 62 presses the separated dirt and dust against the fin or baffle 78 and a build-up of dirt and dust occurs. The location of the fin or baffle 78 at an uppermost point within the bin 62 means that the initial build-up of dirt and dust is located in that area. As the build-up of dirt and dust continues, the accumulated dirt and dust forms builds up around the inner wall of the bin 62 and the accumulation is relatively even and uniform. The provision of the fin or baffle 78 parallel to the direction of the tangential inlet port 32 maximises the amount of separated dirt and dust which can be accommodated in the bin 62.

The airflow from which dirt and larger fluff particles has been separated moves inwardly away from the outer wall 64 of the bin 62and travels back along the exterior wall of the fine dust collector 74 towards the shroud 80. The presence of the shroud 80 also helps to prevent larger particles and fluff traveling from the outer cyclone 54 into the inner cyclone 56, as is known. The air from which comparatively large particles and dirt has been separated then passes through the shroud 80 and travels along the channel between the shroud 80 and the outer surface of the inner cyclone body 72 until it reaches the inlet port 86 to the inner cyclone 56. The air then enters the inner cyclone 56 in a helical manner and follows a spiral path around the inner surface of the cyclone body 72. Because of the frusto-conical shape of the cyclone body 72, the speed of the airflow increases to very high values at which the fine dirt and dust still entrained within the airflow is separated therefrom. The fine dirt and dust separated in the inner cyclone 56 is collected in the fine dust collector 74 outwardly of the dust ring 68. The dust ring 68 discourages re-entrainment of the separated dirt and dust back into the airflow.

When the fine dirt and dust has been separated from the airflow, the cleaned air exits the cyclonic separator via the vortex finder (not shown). The air is passed over or around the motor and fan unit 50 in order to cool the motor before it is expelled into the atmosphere.

As will be appreciated from the above description, it has been found that it is possible to construct a vacuum cleaner having a cylonic dirt and dust separator with the axis or axes of the cyclone or cyclones lying horizontally and without restricting or compromising the separation efficiency of the cyclonic separator. The fin or baffle ensures that the dirt and dust accumulated within the bin is collected in a manner which will discourage re-entrainment and allow the dirt to be collected in an efficient manner. The result is the provision of a vacuum cleaner which has a very small height dimension and is therefore able to pass easily under furniture and other objects which have a small vertical clearance. Prime examples of this type of object are chairs and tables. The invention, as will be seen from the above described example, is particularly applicable to robotic vacuum cleaners which are designed to navigate themselves around a room or other area to be cleaned without human intervention. However, the invention herein described is not concerned with the specific means by which the cleaner is propelled across a surface to be cleaner, nor with the specific means by which the cleaner avoids contact with obstacles or obstructions. Indeed, the cleaner could be powered from the mains using a cable if desired, although it is preferred that the cleaner be operated in a cordless manner. The nature and arrangement of the sensors described above are also immaterial and can be replaced by equivalent arrangements which will be apparent to a skilled reader. It will be understood that the means by which the batteries providing power to the cleaner are charged is also immaterial to the invention, as is the arrangement by which they are attached to and released from the cleaner. The same goes for the exact design and configuration of the cleaner head and the manner by which it is mounted on the chassis. All of these features are to be regarded as non-essential to the central concept of providing a robotic or autonomous vacuum cleaner with cyclonic separating means in the manner described above.

Claims:

1. A vacuum cleaner having a dirty air inlet, a clean air outlet, an airflow path therebetween, and dirt and dust separating apparatus arranged in the airflow path between the dirty air inlet and the clean air outlet, the dirt and dust separating apparatus comprising a centrifugal separator having a cylindrical or tapering chamber with a tangential inlet at a first end and a dirt and dust collecting portion at a second end opposite the first end, an inner wall being located inside the second end of the chamber, wherein the centrifugal separator is located so that the longitudinal axis of the chamber is horizontal and a single fin or baffle is provided on the inner wall so as to extend towards the wall of the chamber in a direction which is substantially parallel to that of the tangential inlet.

2. A vacuum cleaner as claimed in claim 1, wherein the single fin or baffle extends substantially vertically upwardly towards the wall of the chamber.

3. A vacuum cleaner as claimed in claim 1 or 2, wherein the single fin or baffle is located on a portion of the inner wall remote from the first end of the chamber.

4. A vacuum cleaner as claimed in any one of claims 1 to 3, wherein the inner wall is cylindrical or tapering so as to give the dirt and dust collecting portion an annular shape.

5. A vacuum cleaner as claimed in any one of the preceding claims, wherein the single fin or baffle extends between one quarter and three quarters of the distance from the inner wall to the wall of the chamber.

6. A vacuum cleaner as claimed in claim 5, wherein the single fin or baffle extends substantially one half of the distance from the inner wall to the wall of the chamber.

7. A vacuum cleaner as claimed in any one of the preceding claims, wherein the inner wall forms part of a second centrifugal separator located downstream of the said centrifugal separator.

8. A vacuum cleaner as claimed in claim 7, wherein the second centrifugal separator comprises a frusto-conical cyclone having a cone opening located in the second end of the chamber and surrounded by a fine dust collector.

9. A vacuum cleaner as claimed in claim 8, wherein the inner wall forms the fine dust collector.

10. A vacuum cleaner as claimed in claim 8 or 9, wherein a dust ring extends horizontally into the fine dust collector at a radial position between the inner wall and the cone opening.

11. A vacuum cleaner as claimed in any one of claims 7 to 10, wherein a shroud is located immediately upstream of the second centrifugal separator and the single fin or baffle extends outwardly from the inner wall substantially as far as the shroud.

12. A vacuum cleaner as claimed in any one of the preceding claims, wherein the mouth of the tangential inlet is located above the lowermost edge of the cylindrical or tapering chamber.

13. A vacuum cleaner as claimed in claim 12, wherein the tangential inlet is located along or parallel to a vertical tangent to the wall of the cylindrical or tapering chamber.

14. A vacuum cleaner as claimed in any one of the preceding claims, wherein the cleaner further comprises a chassis, supporting wheels and drive means for driving the wheels over a surface to be cleaned.

15. A vacuum cleaner as claimed in claim 14, wherein the cleaner further comprises sensors for sensing objects and obstacles in the path of the cleaner and control means for avoiding contact with the said objects and obstacles.

16. A vacuum cleaner substantially as hereinbefore described with reference to the accompanying drawings.

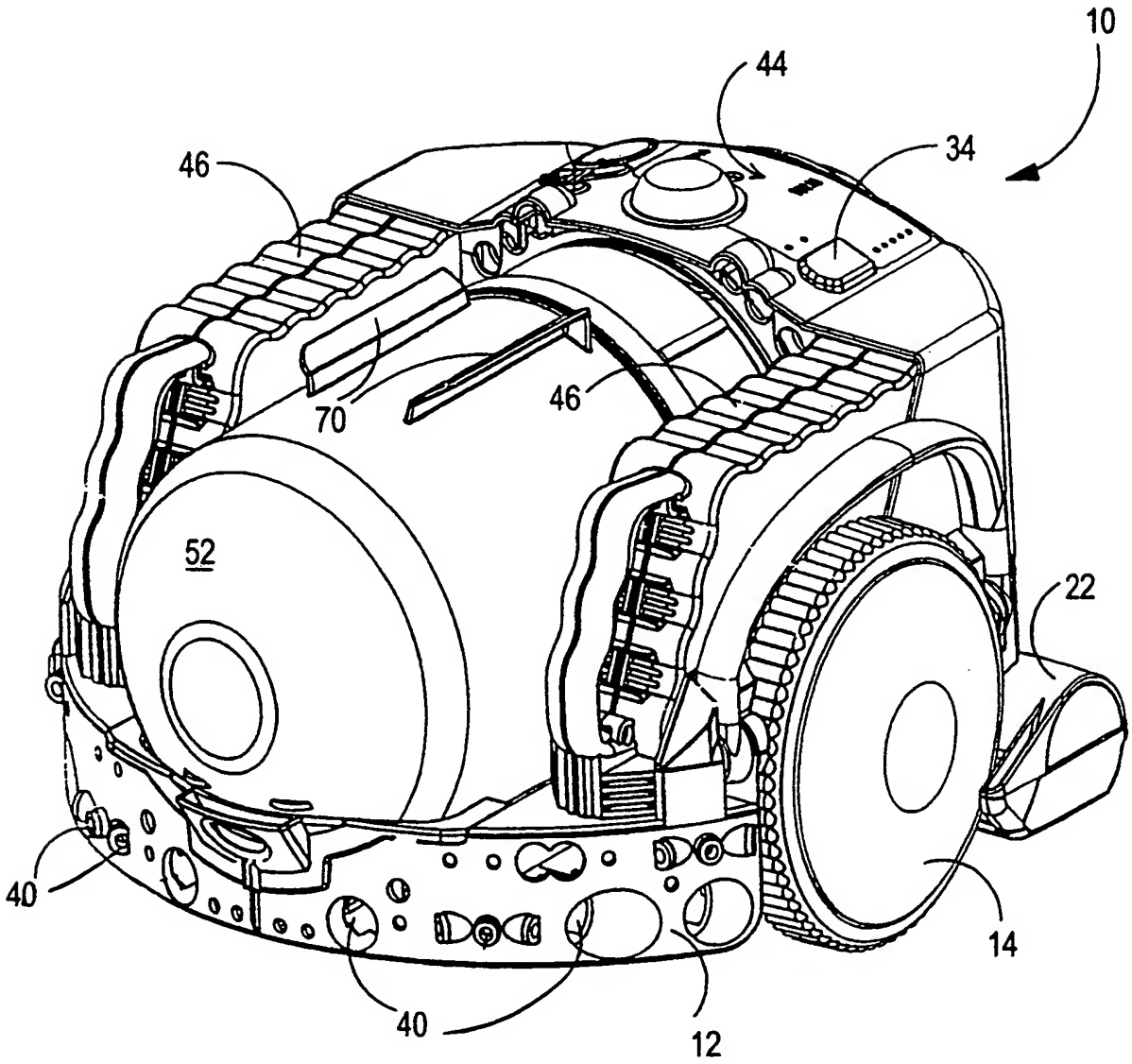


FIG.1.

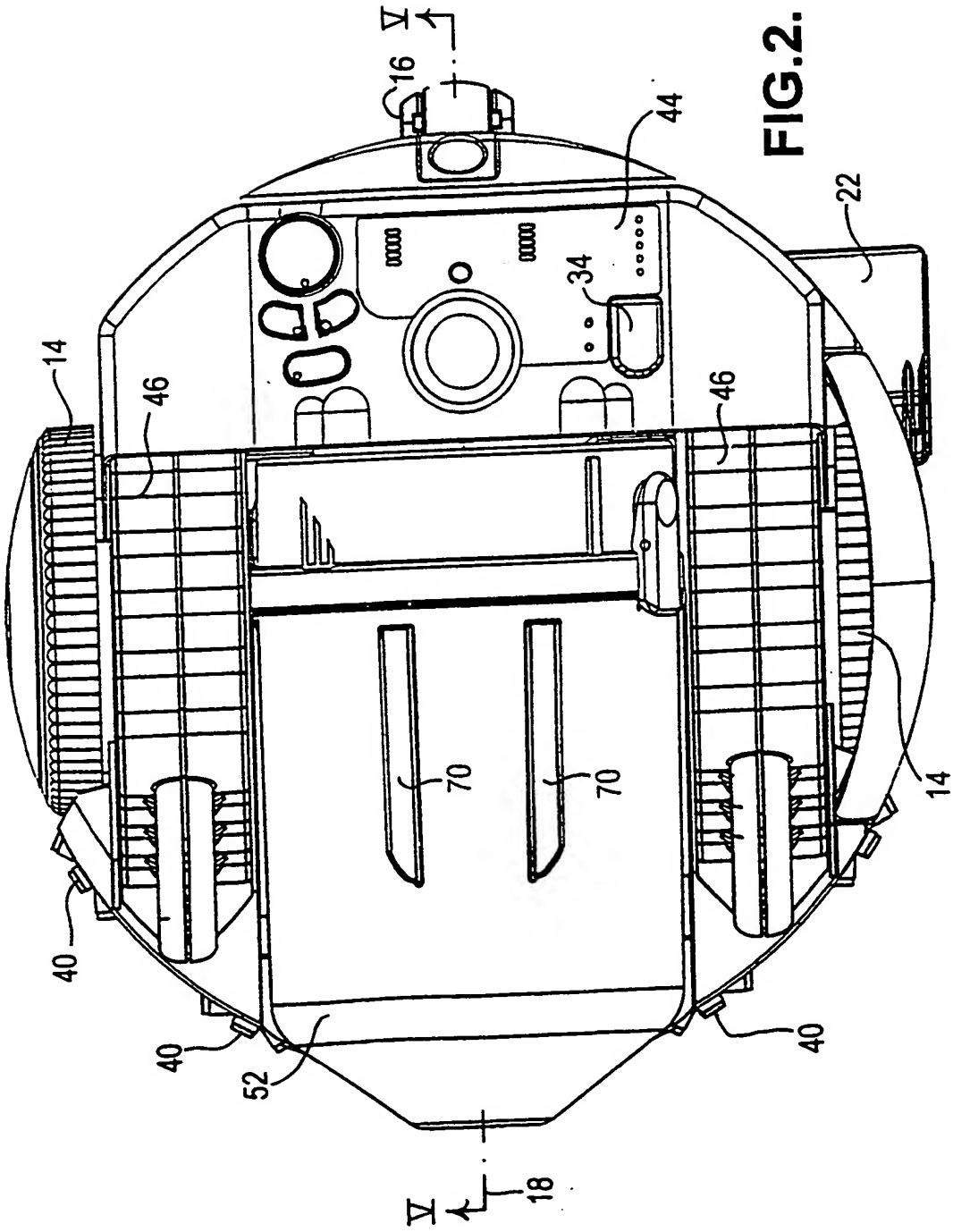


FIG.2.

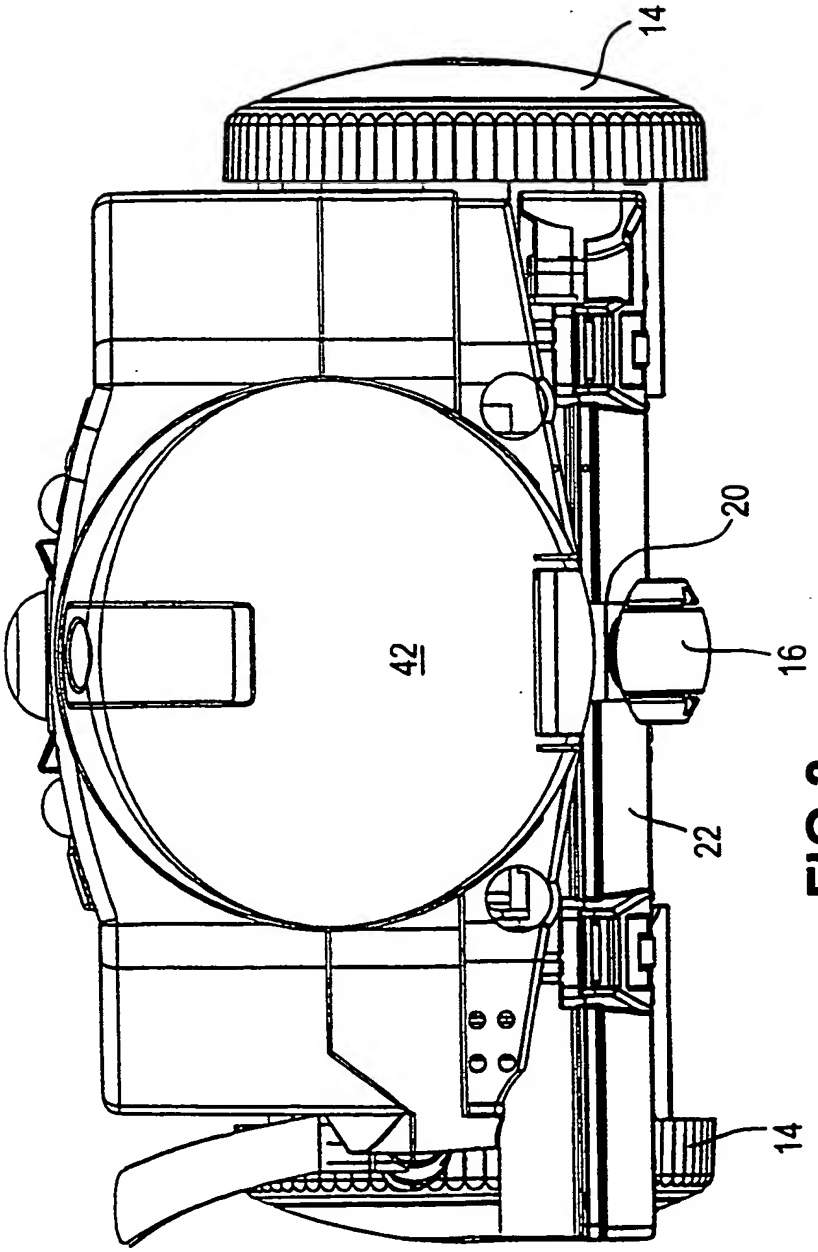


FIG.3.

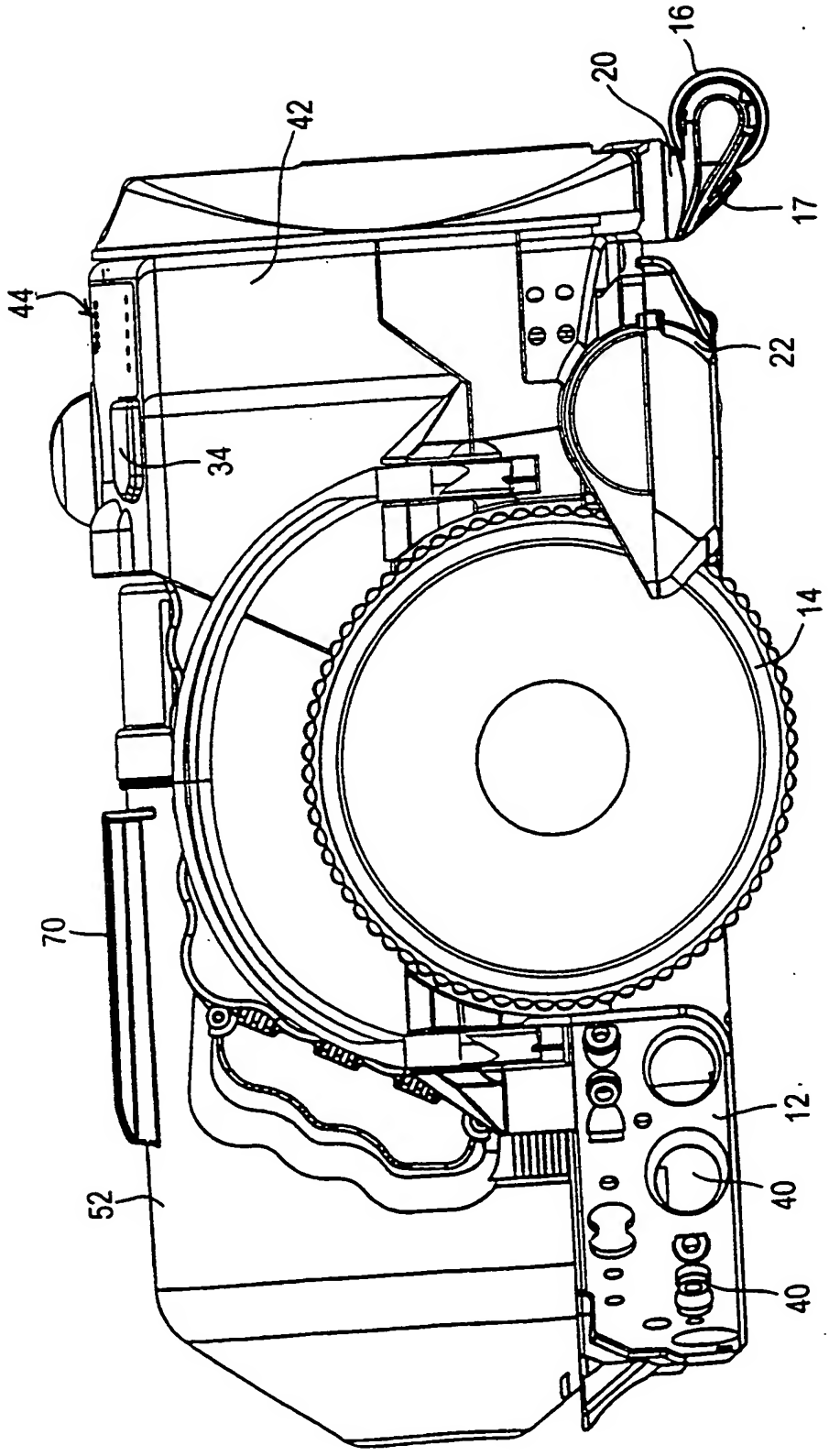


FIG.4.

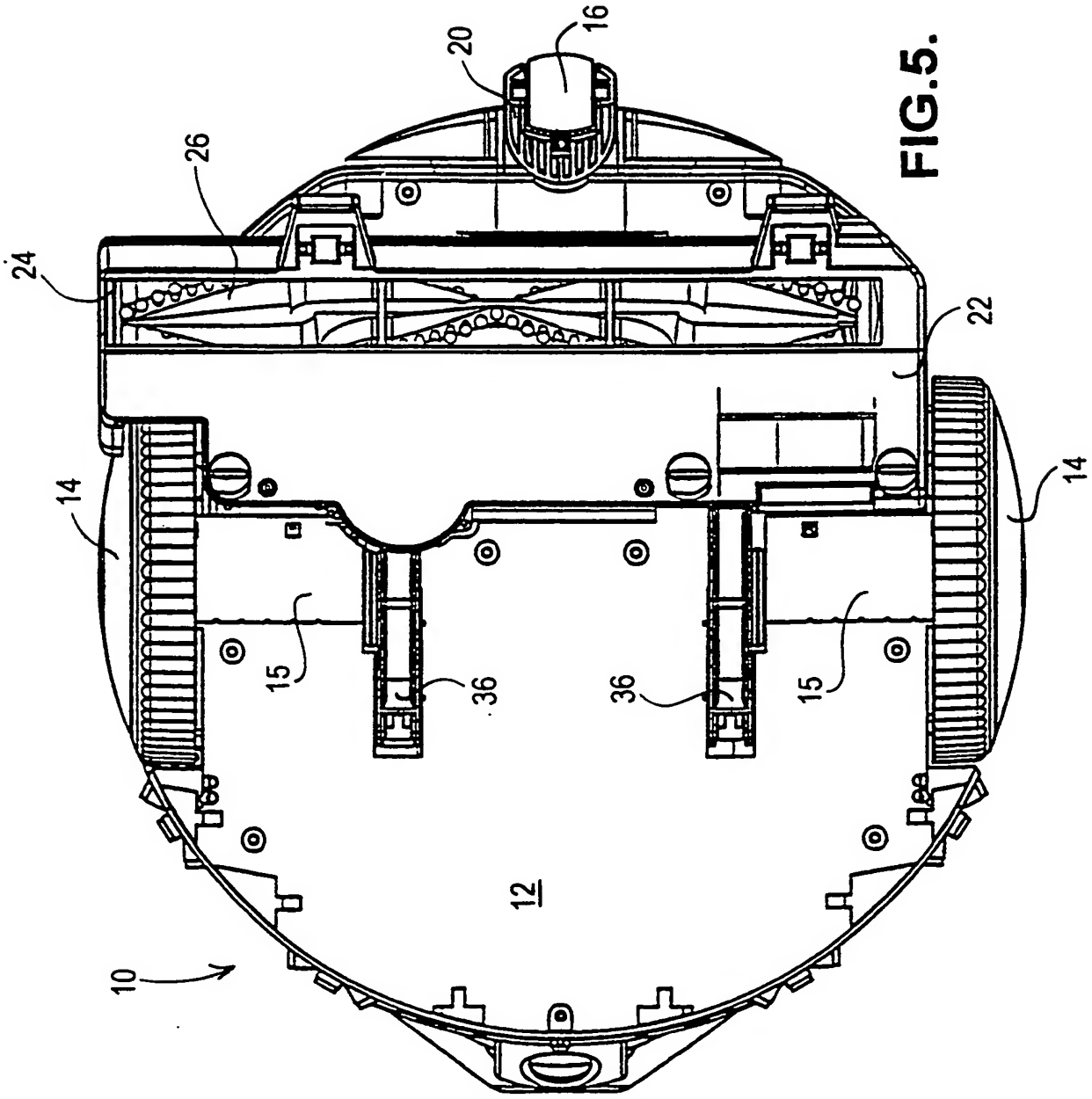
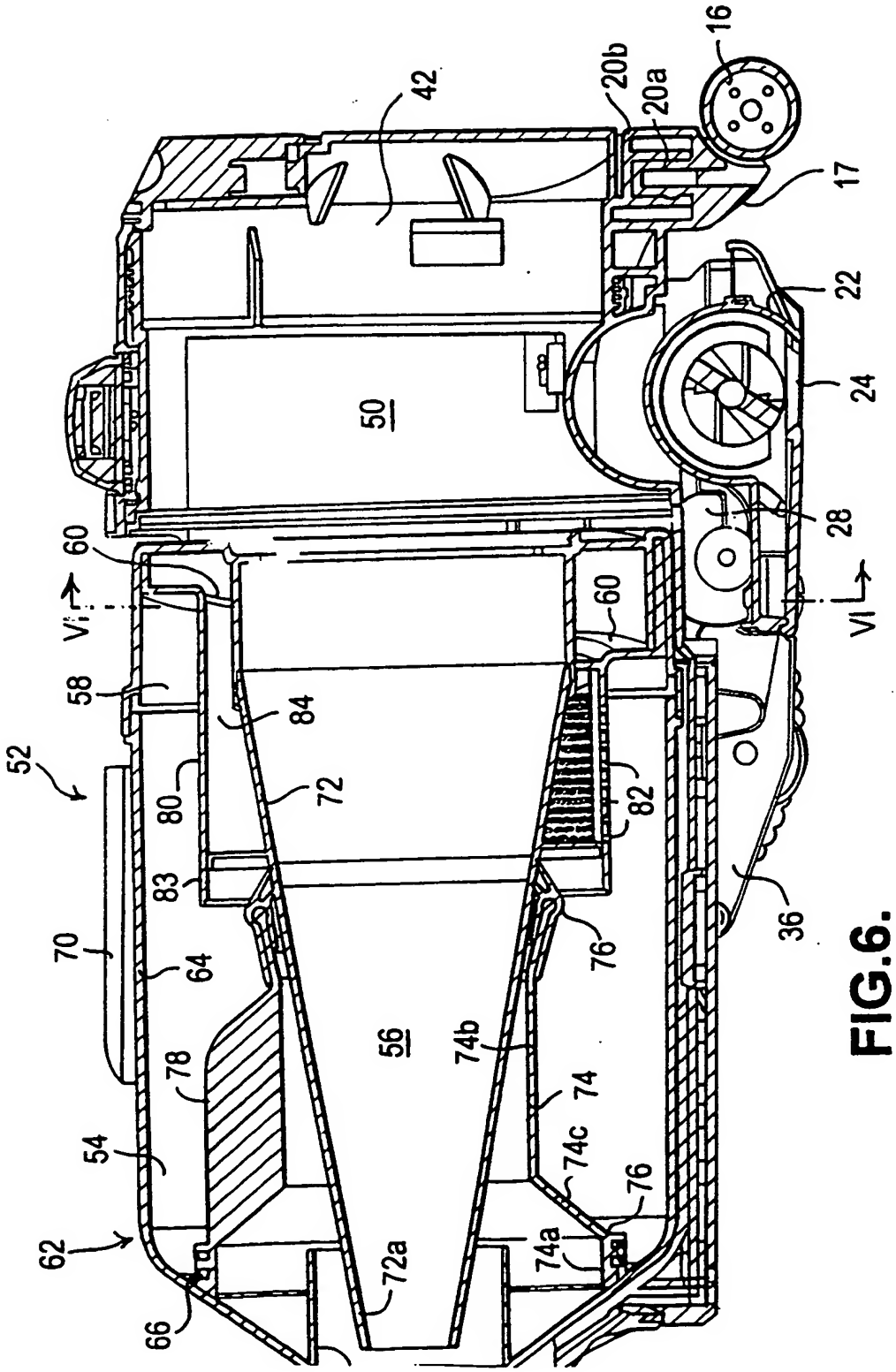


FIG.5.


16
20b
20a
42
17
22
24
50
28
60
VI
VI
58
84
52
72
80
82
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76
56
74b
78
74
54
74c
76
62
72a
74a
66

FIG.6.

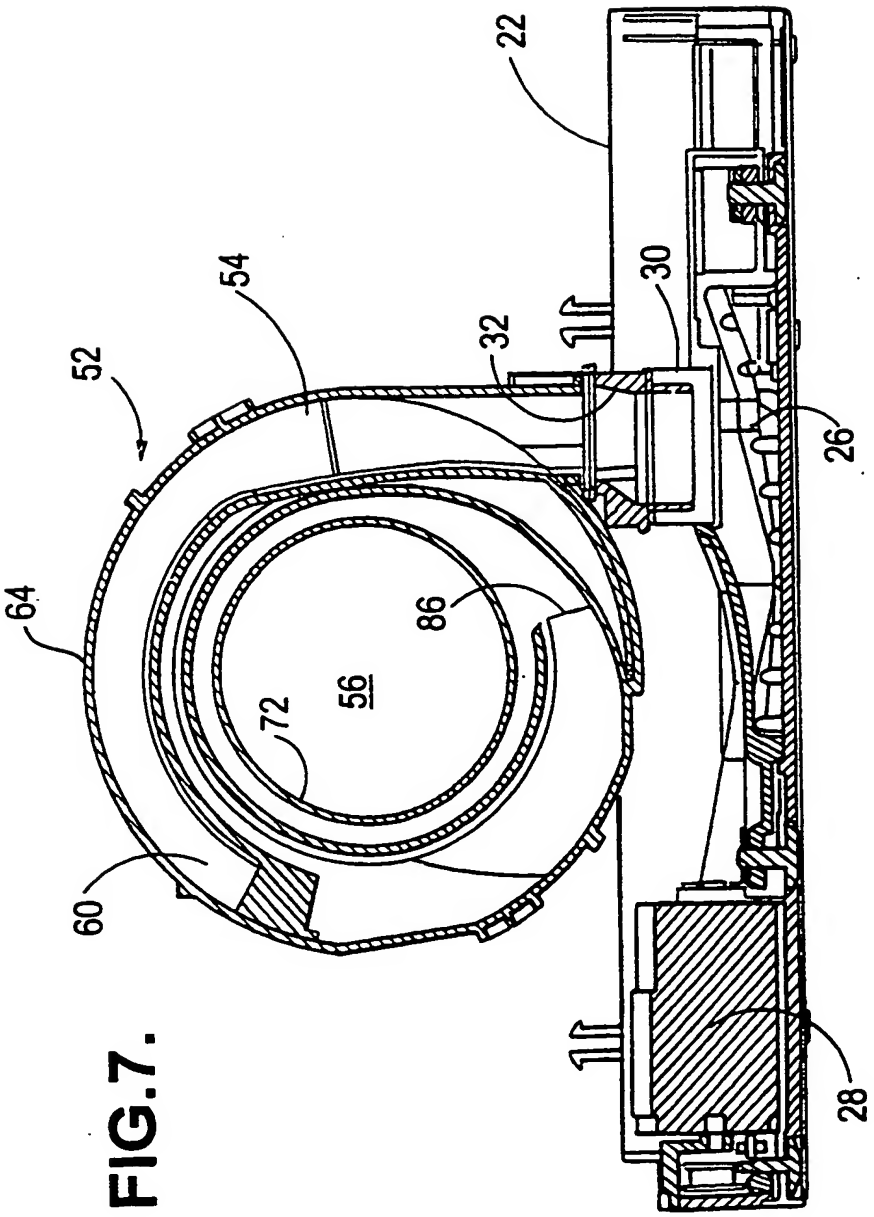

FIG.7.

INTERNATIONAL SEARCH REPORT

Intern onal Application No
PCT/GB 99/04084

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A47L9/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A47L B04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 636 338 A (NOTETRY LTD) 1 February 1995 (1995-02-01) cited in the application abstract column 7, line 11 - line 37 figures 1-3	1,7,8,11
A	US 5 267 371 A (SOLER N V ET AL) 7 December 1993 (1993-12-07) cited in the application abstract figures 1,3-7	1,7,8,11
A	US 2 405 625 A (WHITON L C; WATSON J E) 13 August 1946 (1946-08-13) column 2, line 24 -column 3, line 16 figures	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 March 2000	13/03/2000
Name and mailing address of the ISA	Authorized officer

INTERNATIONAL SEARCH REPORT

Inter onal Application No
PCT/GB 99/04084

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2 298 598 A (NOTETRY LTD) 11 September 1996 (1996-09-11) abstract page 4, paragraph 2 -page 5, paragraph 1 figures	1
A	EP 0 042 723 A (ROTORK APPLIANCES LTD) 30 December 1981 (1981-12-30) cited in the application abstract; figures 1,2	1
A	EP 0 037 674 A (DYSON J) 14 October 1981 (1981-10-14) cited in the application page 9, line 18 -page 12, line 9 figures 4,5	1
A	FR 1 185 149 A (THOMPSON-HOUSTON) 30 July 1959 (1959-07-30) page 2, column 2, line 13 - line 40 figures	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte[illegible]onal Application No
PCT/GB 99/04084

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0636338 A	01-02-1995	US 5078761 A	07-01-1992
		AT 123639 T	15-06-1995
		AT 154216 T	15-06-1997
		AU 637272 B	20-05-1993
		AU 8819491 A	11-06-1992
		CA 2056161 A,C	04-06-1992
		DE 69110424 D	20-07-1995
		DE 69110424 T	01-02-1996
		DE 69126546 D	17-07-1997
		DE 69126546 T	29-01-1998
		EP 0489565 A	10-06-1992
		ES 2105467 T	16-10-1997
		HK 1001469 A	19-06-1998
		HK 1000956 A	15-05-1998
		JP 1948863 C	10-07-1995
		JP 5176871 A	20-07-1993
		JP 6085753 B	02-11-1994
		SG 43964 A	14-11-1997
US 5267371 A	07-12-1993	CA 2061469 A	20-08-1993
		AU 3307193 A	26-08-1993
		EP 0557096 A	25-08-1993
		JP 6054778 A	01-03-1994
US 2405625 A	13-08-1946	NONE	
GB 2298598 A	11-09-1996	AU 4671496 A	23-09-1996
		WO 9627446 A	12-09-1996
		ZA 9601532 A	27-08-1996
EP 0042723 A	30-12-1981	AT 14974 T	15-09-1985
		CA 1182613 A	19-02-1985
		DK 272181 A,B,	20-12-1981
		JP 1440279 C	30-05-1988
		JP 57066728 A	23-04-1982
		JP 62050140 B	22-10-1987
		JP 1440322 C	30-05-1988
		JP 61191329 A	26-08-1986
		JP 62050141 B	22-10-1987
		US 4826515 A	02-05-1989
		US 4853011 A	01-08-1989
		US 4593429 A	10-06-1986
		US 5160356 A	03-11-1992
EP 0037674 A	14-10-1981	AT 14665 T	15-08-1985
		CA 1162362 A	21-02-1984
		DK 137581 A	27-09-1981
		ES 501170 D	01-07-1982
		HK 82386 A	07-11-1986
		JP 1446407 C	30-06-1988
		JP 56152617 A	26-11-1981
		JP 62055416 B	19-11-1987
		MY 10987 A	31-12-1987
		NO 811013 A,B,	28-09-1981
		US 4377882 A	29-03-1983
		US RE32257 E	07-10-1986